Assignment 4 Joshua Goldberg

October 25, 2018

1 Random Forest Binary Classification:

For assignment 4 we will be working with a credit default data set. The data includes various features around financial history and demographic information. The target variable is "default payment next week", which is just a binary flag of whether a customer defaults on a payment in the next week.

You will need to use the **Random Forest Classifier** from sklearn in order to build a classifier to predict if a customer is likely to default. You will also need to use the GridSearch CV for this assignment.

2 Data Processing:

a) Import the data: The target / y variable is "default payment next month" column. Keep all predictors except for the row column (this is a blank in the .xlsx file).

b) Remove any rows that have missing data.

c) Split data into train / test set using an 70/30 split.

```
In [3]: import numpy as np
        import pandas as pd
        import matplotlib.pyplot as plt
        import seaborn as sns
        from sklearn.model_selection import train_test_split, GridSearchCV
        from sklearn.ensemble import RandomForestClassifier
        import sklearn.metrics as metrics
        import sklearn.preprocessing as preprocessing
        # We'll use this library to make the display pretty
        from tabulate import tabulate
        import warnings
        warnings.filterwarnings("ignore")

In [4]: credit_df = pd.read_excel("default of credit card clients.xls")

        credit_df.replace(["NaN", "NaT"], np.nan, inplace=True)
        credit_df = credit_df.dropna(how="any", axis=0)
```

```
X_train, X_test, y_train, y_test = train_test_split(
    credit_df.drop(["default payment next month"], axis=1),
    credit_df["default payment next month"], test_size=.30,
    random_state=0)
```

3 Random Forest Classifier - Base Model:

Start by creating a simple Random Forest only using default parameters.

a) Use the RandomForestClassifier in sklearn. Fit your model on the training data.

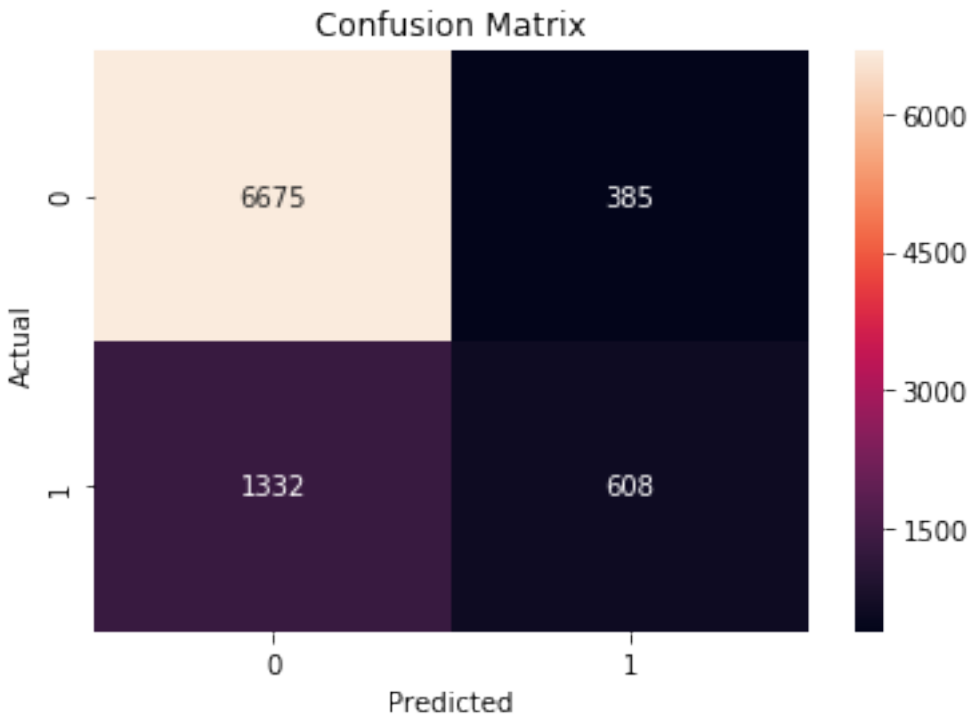
b) Use the fitted model to predict on test data. Use the .predict_proba() and the .predict() methods to get predicted probabilities as well as predicted classes.

c) Calculate the confusion matrix and classification report (both are in sklearn.metrics). These are the same tools from HW #3.

d) Calculate the roc_auc_score for this model. There are many ways to do this, but an example is to use the probabilities from step B and utilize the roc_auc_score from sklearn.

Documentation: http://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_auc_score.html (Links to an external site.)Links to an external site.

In [5]:
```
rf_mod_base = RandomForestClassifier().fit(X_train, y_train)
y_test_prob_base = rf_mod_base.predict_proba(X_test)
y_test_pred = rf_mod_base.predict(X_test)

conf_mat = metrics.confusion_matrix(y_true=y_test,
                                    y_pred=y_test_pred)
plt.title('Confusion Matrix')
sns.heatmap(conf_mat, annot=True, fmt="d")
plt.ylabel("Actual")
plt.xlabel("Predicted")
plt.show()

print(metrics.classification_report(y_test, y_test_pred))

# limit to probability for class = 1
rf_mod_base_probs = rf_mod_base.predict_proba(X_test)[:, 1]

# calculate roc_auc_score
print(f"ROC: {metrics.roc_auc_score(y_test, rf_mod_base_probs)}")
```



	precision	recall	f1-score	support
0	0.83	0.95	0.89	7060
1	0.61	0.31	0.41	1940
avg / total	0.79	0.81	0.78	9000

ROC: 0.7249619608072193

4 Random Forest Classifier - Grid Search:

Start by creating a simple Random Forest only using default parameters.

a) Use the RandomForestClassifier along with the GridSearchCV tool. Run the GridSearchCV using the following:

- n_estimators: 500, 750, 1000
- max_features: 2, 4, 6

Note: *Feel free to try out more parameters, the above is the bare minimum for this assignment.*

Use 5 cross-fold and for scoring use "roc_auc" (this is the score that will be referenced when identifying the best parameters).

Example of GridSearchCV:

create a dictionary of parameters > param_grid = {'max_depth':[2, 4, 6, 8], 'min_samples_split':[3,4,5,6,7,8], 'random_state':[0]}

create Random Forest model > rf_obj=RandomForestClassifier()

Create gridsearch object with various combinations of parameters > rf_Grid = GridSearchCV(rf_obj, param_grid, cv = 5, scoring = 'roc_auc',refit = True, n_jobs=-1, verbose = 5)

Next, just fit this object Documentation: http://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html

b) Identify the best performing model:

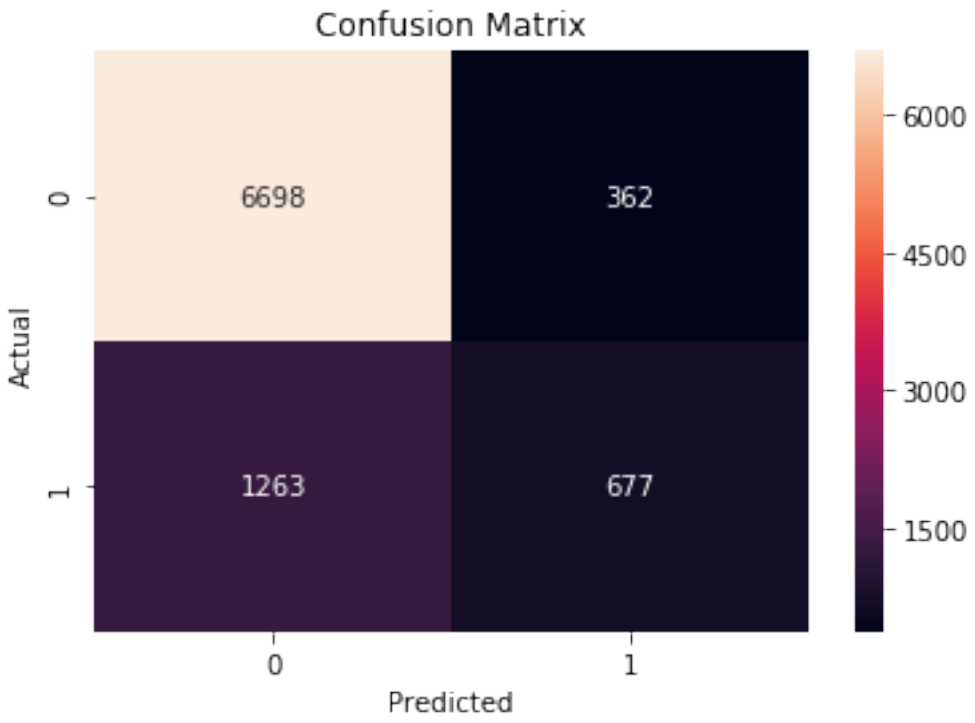
- .best_params_() : This method outputs to best performing parameters
- .best_estimator_() : This method outputs the best performing model, and can be used for predicting on the X_test

c) Use the best estimator model to predict on test data. Use the .predict_proba() and the .predict() methods to get predicted probabilities as well as predicted classes.

d) Calculate the confusion matrix and classification report (both are in sklearn.metrics).

e) Calculate the roc_auc_score for this model.

```
In [6]: # create a dictionary of parameters
        param_grid = {"n_estimators": [500, 750, 1000], "max_features": [2, 4, 6],
                      "random_state": [0]}

        # create random forest model
        rf_obj = RandomForestClassifier()

        # Create gridsearch object with various combinations of parameters
        rf_grid = GridSearchCV(rf_obj, param_grid, cv=5, scoring="roc_auc",
                               refit=True, n_jobs=-1)

In [7]: rf_grid_model_fit = rf_grid.fit(X_train, y_train)
        rf_best_model = rf_grid_model_fit.best_estimator_

In [8]: y_test_pred_grid = rf_best_model.predict(X_test)
        y_test_probs_grid = rf_best_model.predict_proba(X_test)[:, 1]

        conf_mat = metrics.confusion_matrix(y_true=y_test,
                                            y_pred=y_test_pred_grid)
        plt.title("Confusion Matrix")
        sns.heatmap(conf_mat, annot=True, fmt="d")
        plt.ylabel("Actual")
        plt.xlabel("Predicted")
        plt.show()

        print(metrics.classification_report(y_test, y_test_pred_grid))

        # calculate roc_auc_score
        print(f"ROC: {metrics.roc_auc_score(y_test, y_test_probs_grid)}")
```



	precision	recall	f1-score	support
0	0.84	0.95	0.89	7060
1	0.65	0.35	0.45	1940
avg / total	0.80	0.82	0.80	9000

```
ROC: 0.7742645877748898
```

4.1 What are the best parameters from the Grid Search? Does the Model from #3 outperform Model #2?

```
In [9]: print(f"Best parameters: {rf_grid_model_fit.best_params_}")
        print(f"Model #2 ROC of {metrics.roc_auc_score(y_test, rf_mod_base_probs)} \nModel #3 R
```

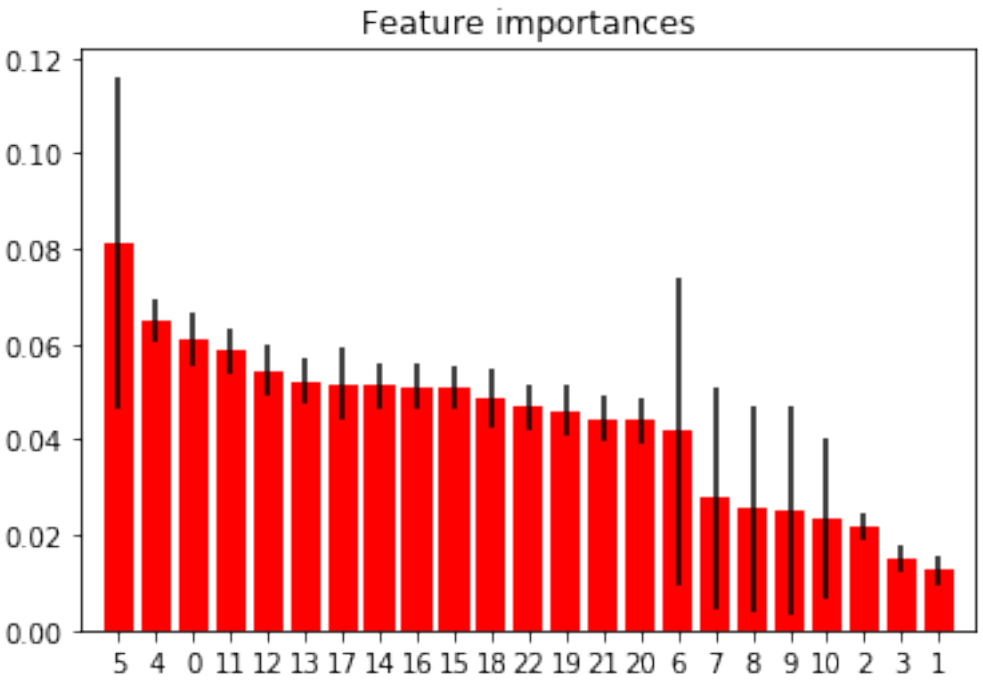
```
Best parameters: {'max_features': 2, 'n_estimators': 1000, 'random_state': 0}
Model #2 ROC of 0.7249619608072193
Model #3 ROC of 0.7742645877748898
```

Model 3 is superior in ROC. Precision, recall, and f1-score are slightly better.

4.2 Create a feature importance plot for your best performing model. What are the top 5 features for this model?

```
In [22]: importances = rf_best_model.feature_importances_
         std = np.std([tree.feature_importances_ for tree in rf_best_model.estimators_],
                      axis=0)
         indices = np.argsort(importances)[::-1]

         # Print the feature ranking
         headers = ["name", "score"]
         values = sorted(zip(X_test.columns, importances), key=lambda x: x[1] * -1)
         print(tabulate(values[0:5], headers, tablefmt="plain"))

         # Plot the feature importances of the forest
         plt.figure()
         plt.title("Feature importances")
         plt.bar(range(X_test.shape[1]), importances[indices],
                color="r", yerr=std[indices], align="center")
         plt.xticks(range(X_test.shape[1]), indices)
         plt.xlim([-1, X_test.shape[1]])
         plt.show()
```

```
name           score
PAY_0      0.0812772
AGE        0.0649611
LIMIT_BAL  0.0608625
BILL_AMT1  0.0585223
BILL_AMT2  0.0544506
```


Feature importances
0.12
0.10
0.08
0.06
0.04
0.02
0.00
5 4 0 11 12 13 17 14 16 15 18 22 19 21 20 6 7 8 9 10 2 3 1